

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 36

USING THE SIGNAL GENERATOR AND SIGNAL TRACER TO TROUBLESHOOT

- 36-1. Signal Sources**
- 36-2. Signal Tracers**
- 36-3. Troubleshooting With The Signal Generator**
- 36-4. Troubleshooting With The Signal Tracer**
- 36-5. Alignment of AM Broadcast Receivers**
- 36-6. Alignment of FM Receivers**



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Service Practices 36

INTRODUCTION

The experienced serviceman is able to localize a great many defects in a receiver through analysis of the symptoms. For example, when he is working on a receiver that has a high hum level, the experienced serviceman adjusts the volume control to see whether the hum level is affected. If it is not, he knows that the hum is in the audio section of the receiver. From past experience he knows that the most likely source of the trouble is in the filter section of the power supply.

But suppose that the symptoms of the trouble are not as clear cut as this? Let us say that the receiver is dead, or very weak. Where is the defective stage? It can probably be located by making voltage and resistance measurements. Since the serviceman does not know what stage is defective, it is necessary for him to check stage after stage until an abnormal voltage reading or resistance reading is found.

But there are ways of shortening the time required to find which stage is defective. Using these ways, no time is wasted in checking stages that are operating properly. Once you eliminate properly opera-

ting stages, voltage or resistance measurements are then made only in the defective stage to locate the inoperative component.

One way of shortening troubleshooting time involves making *dynamic* checks, using either the signal-injection method or the signal-tracing method of troubleshooting. These dynamic methods shorten the troubleshooting time required to locate defects that could otherwise be found only by laborious stage-by-stage voltage or resistance checks. As a matter of fact, there are many defects that can cause a receiver to be inoperative without changing either the d-c voltage measurements or the resistance measurements. Such troubles cannot be found except through a dynamic testing method — either the signal-tracing method or the signal-injection method.

The basic principle of the signal injection method is shown in Fig. 36-1. The loudspeaker of the receiver under test (or an output meter connect across its voice coil terminals) is used as the indicator. An audio signal, obtainable from a number of sources to be described later, is applied to point 1. If the signal is heard in the loudspeaker, or indicated on the meter, there is no defect between point 1 and the loudspeaker.

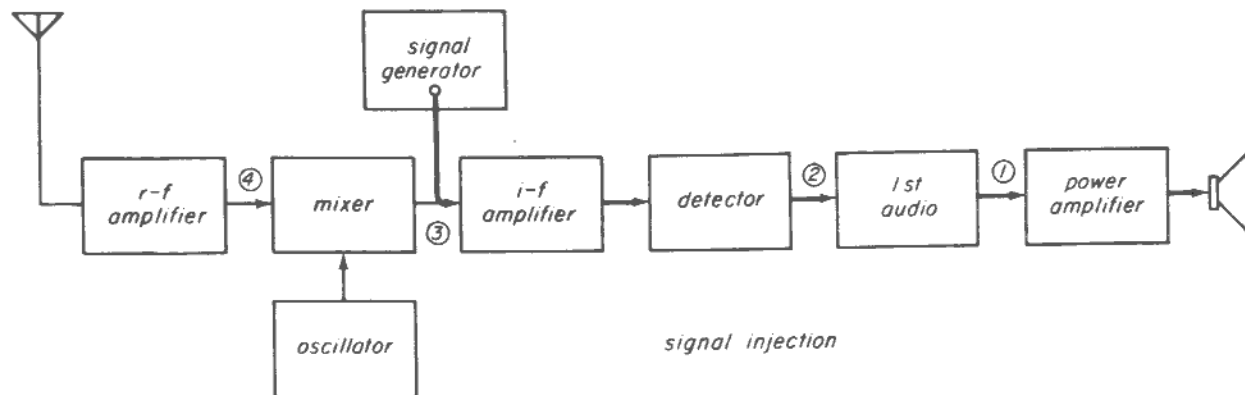


Fig. 36-1

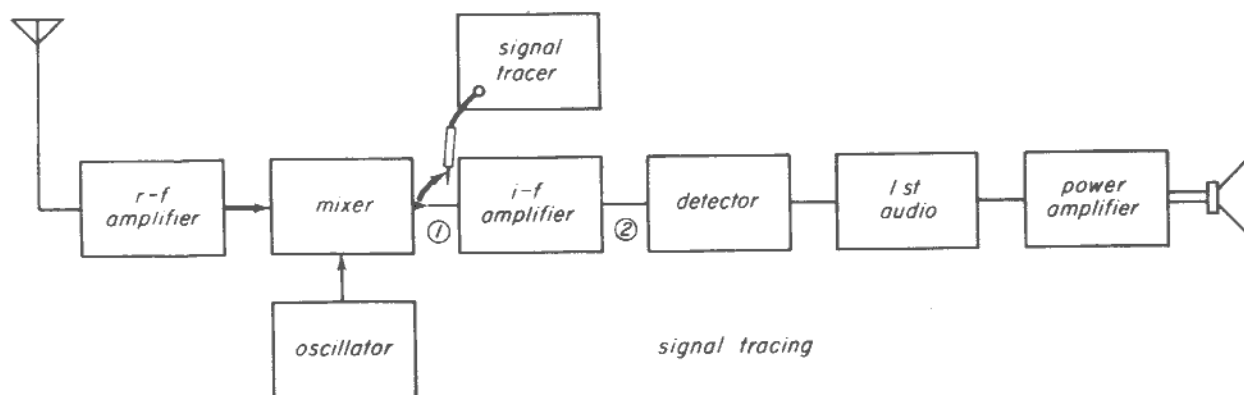


Fig. 36-2

er. The signal is then applied to point 2. Again, if the signal is present in the output, there is no defect between point 2 and the loudspeaker. The next point to which the test signal is to be applied is point 3. Here, however, the signal must be changed to a modulated intermediate-frequency signal. At this setting of the signal generator, the i-f stage or stages can be checked. Point 4 is the next test point, but the signal generator again needs to be changed to supply an amplitude modulated signal at an r-f frequency. In this way, the entire receiver is tested, with the nature and frequency of the test signal being changed according to the circuit to which it is applied. The basic characteristic of the signal-injection method of testing is that the test signal is applied at or near the loudspeaker and is moved toward the input end of the receiver as the testing progresses. Also, the loudspeaker of the receiver being tested is used as the output indicator.

The basic principle of the signal-tracing method of dynamic troubleshooting is shown in Fig. 36-2. The signal tracer contains its own amplifiers, detector, and loudspeaker. The probe of the signal tracer is first applied to point 1 in the circuit. If a signal is heard in the loudspeaker of the signal tracer, it indicates that there is no defect between the antenna and point 1. The probe of the signal tracer is then applied to point 2. Again, if the signal is heard in the loudspeaker of the tracer it indicates that there is no defect between the antenna and point 2. In this way, the actual signal passing through the receiver is traced as it travels through the receiver. The defective stage is located when the signal being traced is lost or becomes abnormal. Thus, in this method testing starts

at or near the antenna and moves toward the loudspeaker as the testing progresses.

36-1. SIGNAL SOURCES

Signals for use in the signal injection method of testing can be obtained from a number of sources.

For shop work, the best source is a good AM signal generator. You have already learned the principle of operation of such generators, as well as the features and circuit details of a number of commercial instruments. The signal generator should have an r-f output whose level can be controlled, provision for modulating the r-f output, and provision for obtaining audio output signal directly. Some typical commercial instruments that are well suited for the signal injection method of servicing are shown in Fig. 36-3.

For service calls in the home, more compact signal sources may be desirable. One such device is a high-frequency vibrator. A schematic diagram of a high-frequency vibrator is shown in Fig. 36-4. The output wave form is approximately a square wave, as shown in Fig. 36-5, and is very rich in harmonics. It contains energy at all frequencies from a few hundred cycles up to several megacycles. It provides, without tuning, a source of signal for testing both the r-f and a-f portions of the receiver. Of course, the audio output produced by such a signal is not a pure tone, but is more like a rasping noise. Therefore, it cannot be used to locate the source of distortion or similar defects. It is used mainly for locating weak or dead stages.

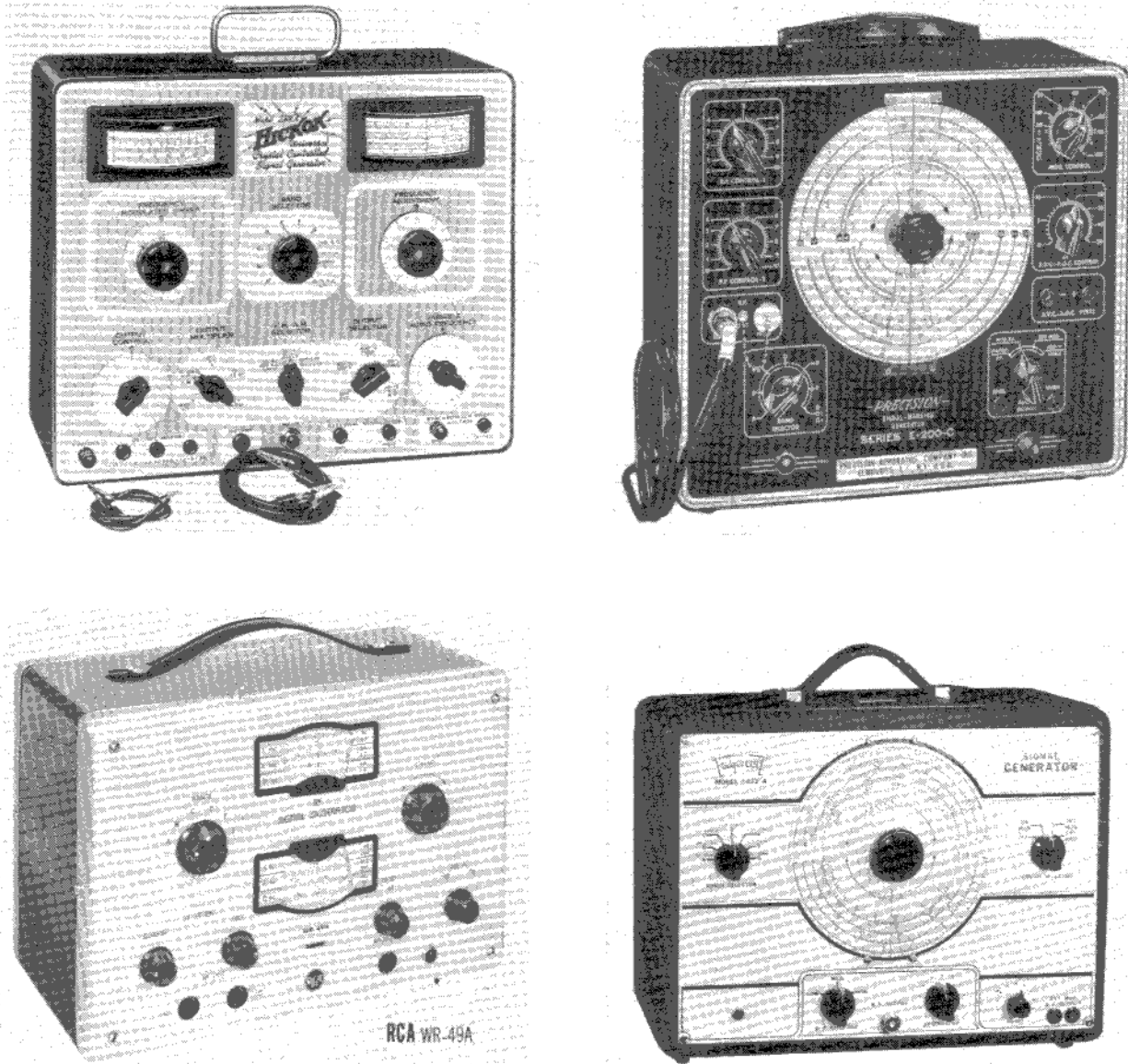


Fig. 36-3

A working receiver can be used as a source of signal for testing another receiver. The receiver used should be an a-c type that has a power transformer to minimize the possibility of shocks or short circuits when connecting to other chassis. Figure 36-6 shows how an audio signal can be extracted from a receiver for test purposes. The amount of signal can be varied by adjusting the volume control. It is necessary to disable the loudspeaker of the receiver supplying the signal so that it does not interfere with the testing. I-F and r-f signals may also be obtained for testing purposes, as shown in the figure. The leads used should be as short as possible. When using a radio

receiver in this way for this purpose, it is convenient to wire a switch so that a resistor may be substituted as a dummy load for the loudspeaker. First tune in a signal on the receiver supplying the signal. Check the receiver supplying the signal and check by listening to it in its own loudspeaker. Then

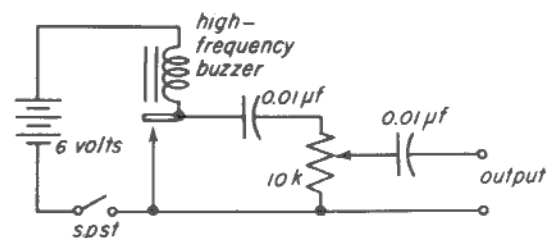


Fig. 36-4

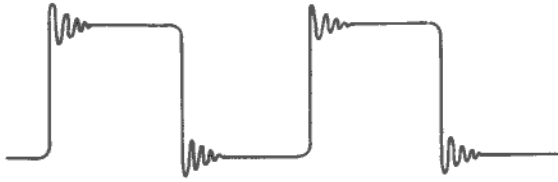


Fig. 36-5

switch the loudspeaker out and apply the signal to the receiver under test.

When no other signal source is available, the audio stages can be checked by injecting 60-cycle a-c voltage from a filament winding through an $0.05\text{-}\mu\text{f}$ capacitor. The details of this method have been described in detail in other booklets.

by both amplifiers in the tester. If the amplifiers are tuned amplifiers, the instrument may be harder to use. Most signal tracers are untuned. If the signal at the point being tested is an audio signal, there is no need to use the detector probe or the first amplifier. Apply the direct probe to the point under test.

A Typical Commercial Signal Tracer. Most commercial signal tracers are sold in kit form for assembly by the buyer. A typical commercial instrument of this type is the Heathkit Visual-Aural Signal Tracer, Model T-3. The complete instrument is shown in Fig. 33-8. It consists essentially of a detector probe, a

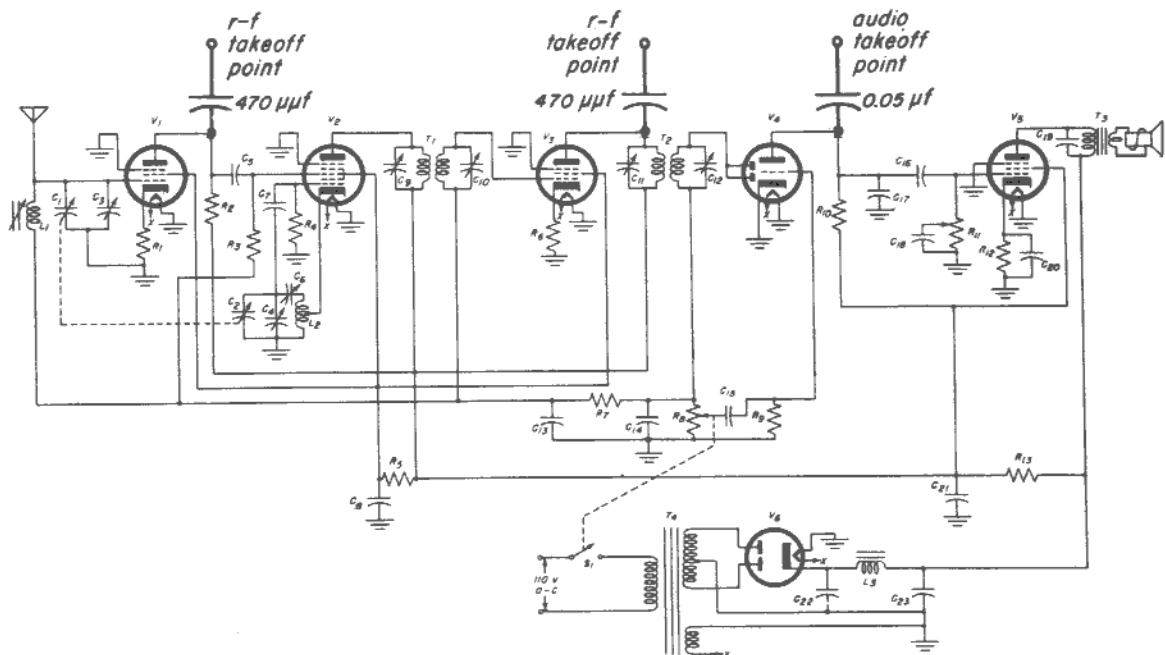


Fig. 36-6

36-2. SIGNAL TRACERS

A signal tracer is essentially a radio receiver, containing amplifier stages, a detector, and a loudspeaker. An output meter or an electron-ray tube output indicator may be included in a signal tracer.

A block diagram showing a typical signal tracer is given in Fig. 36-7. The entire signal tracer should be used if the signal at the point being tested is a modulated r-f signal. Apply the detector probe to the point being tested. The detected signal will be amplified

three-stage amplifier, a loudspeaker, and an electron-ray tube visualizer. There is also provision for using the output transformer and loudspeaker separately for testing purposes. In addition, there is a wattmeter cir-

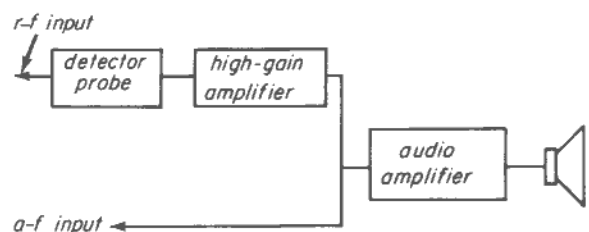


Fig. 36-7

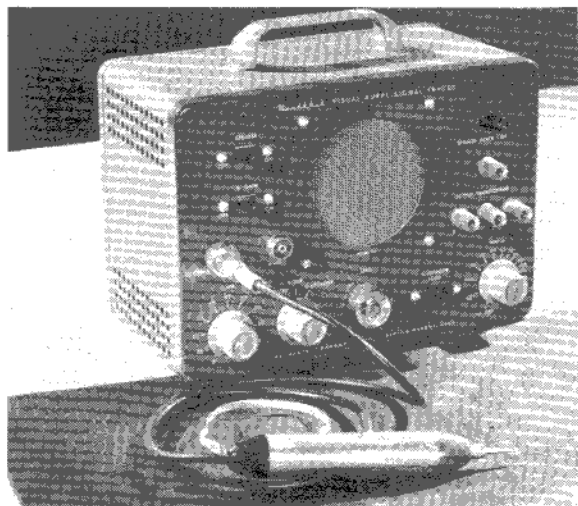


Fig. 36-8

circuit for measuring the approximate wattage consumption of electrical devices, and a noise test circuit.

A simplified block diagram of this signal tracer is shown in Fig. 36-9. As can be seen from this diagram, the detector probe and the

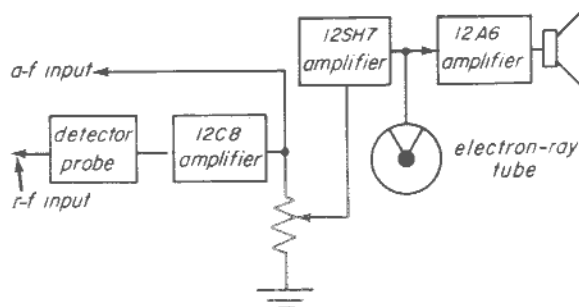


Fig. 36-9

entire three-stage amplifier are used for tracing r-f modulated signals. A direct probe and the two stage audio amplifiers are used for tracing audio signals.

Figure 36-10 shows the complete schematic diagram of the instrument. The components involved in the noise-circuit test, the 100 k-ohm and 470 k-ohm resistors form a voltage divider across the B+ supply, producing about 175 volts at their junction. In order to use the noise-test feature, the function switch should

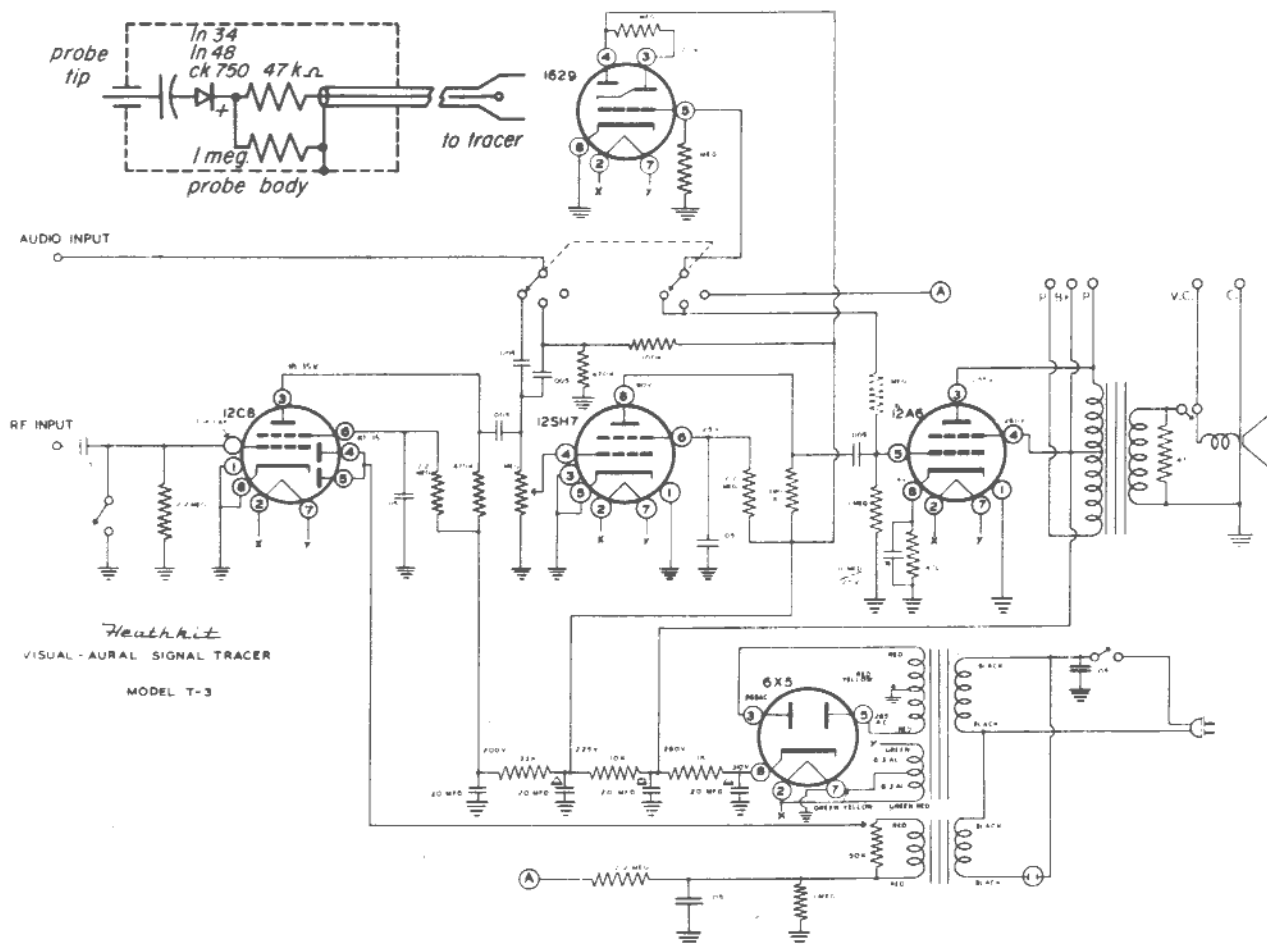


Fig. 36-10

be set to its center position. This switch setting puts the d-c voltage onto the direct probe for application to suspected components. If for application to suspected components. If there is no defect in the circuit to which the probe is applied, a sharp, clear click will be heard in the signal-tracer loudspeaker. This click is caused by the charging up of the 0.005- μ f capacitor. If there is any defect in the circuit that causes a varying d-c current flow—such as rosin or cold-soldered joints, intermittently shorting capacitors, noisy resistors or controls—the varying d-c current through the 100 k-ohm resistor will cause crackling or frying noises in the loudspeaker of the signal tracer. The noise test should be performed with all power removed from the receiver being tested.

The wattmeter circuit is also shown in the circuit diagram. When the device whose wattage consumption is to be measured is plugged into the wattmeter outlet shown in the lower right-hand corner of the diagram, current drawn by the device flows through the primary of the current transformer. The a-c voltage induced in the secondary transformer is rectified by the two diodes of the 12C8 tube and applied to the electron-ray tube. The greater the current drawn by the device, the higher will be the voltage induced across the 50 k-ohm resistor, and the less will be the voltage that must be tapped off with the variable resistor in order to close the electron-ray tube. Thus, the variable resistor can be calibrated in watts.

36-3. TROUBLESHOOTING WITH THE SIGNAL GENERATOR

This discussion of the use of a signal generator for troubleshooting is based on the schematic diagram of a typical superheterodyne receiver shown in Fig. 36-11.

The troubleshooting procedure should be organized so that you can locate troubles in the shortest possible time. First make visual checks, such as seeing that all the tubes are in their sockets, properly seated, and lit. To use the signal generator and make half a dozen or more tests only to find that a tube is defective because it has an open filament is certainly not an efficient procedure. Such defects should be discovered immediately by an organized inspection of the chassis and its tubes. Also, when you are faced with a completely dead receiver, you should check the power-supply voltages first. The receiver cannot be expected to function without proper operating voltages. If the B+ voltages are low, the receiver should be promptly disconnected to prevent the possibility of damage due to a B+ short. If these preliminary checks do not disclose trouble, adjust the signal generator and connect the proper cables to obtain an audio output signal. Turn the audio output control to maximum and apply the signal-generator cable across the voice-coil terminals, point 1, of the loudspeaker. With the output available from most signal generators,

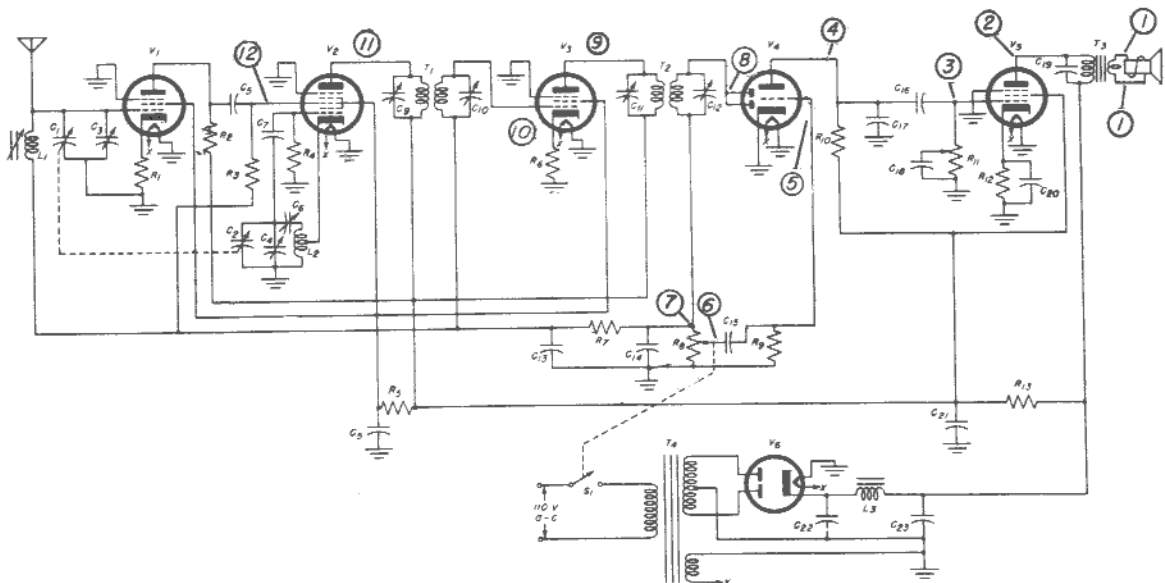


Fig. 36-11

a low-volume audio note should be heard. Otherwise trouble in the loudspeaker is indicated.

Next, transfer the cable of the signal generator to the plate of the output tube, point 2. A blocking capacitor—about $0.05\ \mu\text{f}$, 600 volts—should be used in series with the hot side of the cable unless you are *sure* that there is a d-c blocking capacitor inside the generator. You should hear the output of the signal generator somewhat louder in the loudspeaker. Otherwise, an open primary or secondary winding in the output transformer is indicated.

The next test point is at the grid of the output tube, point 3. You should hear the generator signal considerably amplified in the loudspeaker. The average gain of the output stage in a standard broadcast superheterodyne receiver is about 10 to 20. If the audio output control of the signal generator is calibrated, you can make rough gain measurements by connecting an output meter across the voice-coil terminals and readjusting the output control to maintain the same output on the meter. The amount that the input signal must be reduced to keep the output constant when moving from the plate to the grid of a stage will give a rough indication of the gain in that stage. If you do not hear any output when the signal applied to the grid of the output tube, you have the localized inoperative stage. Then you can locate the defective component by a combination of voltage and resistance measurements. Possible causes for an inoperative output stage are a defective tube, improper plate or screen voltages, an open cathode resistor, and an open screen by-pass capacitor.

Coupling capacitor C_{16} can be checked next by applying the signal to a plate of the first audio amplifier tube, point 4. At most, a slight reduction in the output signal is normal at this point. If the signal disappears or becomes very weak, check for an open C_{16} or a shorted C_{17} . The next test point is the grid of the first audio amplifier, point 5. You should hear a considerably amplified signal in the output. Otherwise, check for a defective tube for proper plate voltage on this tube.

Next, apply the audio signal from the generator in turn to the other side of capacitor C_{15} , point 6, and to the high side of the volume control, point 7. At maximum setting of the control, the signal in the loudspeaker should be just as loud as at the previous test point, and the volume control should smoothly reduce the output from this maximum to zero.

For further testing, change the generator signal to an amplitude-modulated signal at the intermediate frequency. First, apply this signal to the diode detector plates, point 8. If this circuit is working properly, the input signal should be demodulated and amplified by the audio amplifier, which has previously been checked. No output at this test point may indicate either a defective detector tube or an open winding in the i-f transformer secondary. If you have not found a defect, continue testing by moving the signal injection point back stage-by-stage toward the antenna. The next test point is at the plate of the i-f amplifier tube, point 9. Again, make sure to use a d-c blocking capacitor if there is none in the signal generator. For r-f output signals, a capacitor of about $1,000\ \mu\text{mf}$ may be used. If you do not hear the signal at this test point the trouble is most probably a shorted, misaligned, or open i-f transformer winding.

In order to test the operation of the i-f amplifier tube, apply the signal to the grid of that tube, point 10. No output at this test point may be due to a defective tube, improper plate or screen voltages, open cathode resistor, or an open screen bypass capacitor.

Check the operation of the i-f transformer T_1 by applying the signal to the plate of the mixer tube, point 11. Usually, a slight loss in signal when passing through an i-f transformer is to be expected. If the signal becomes very weak, check for misaligned or defective i-f transformers.

The function of the mixer tube is to produce a signal at the intermediate frequency by heterodyne action between the local-oscillator signal and the incoming radio-frequency signal. Therefore, in order to test the mixer action, you must change the output signal of the generator. Adjust the generator to

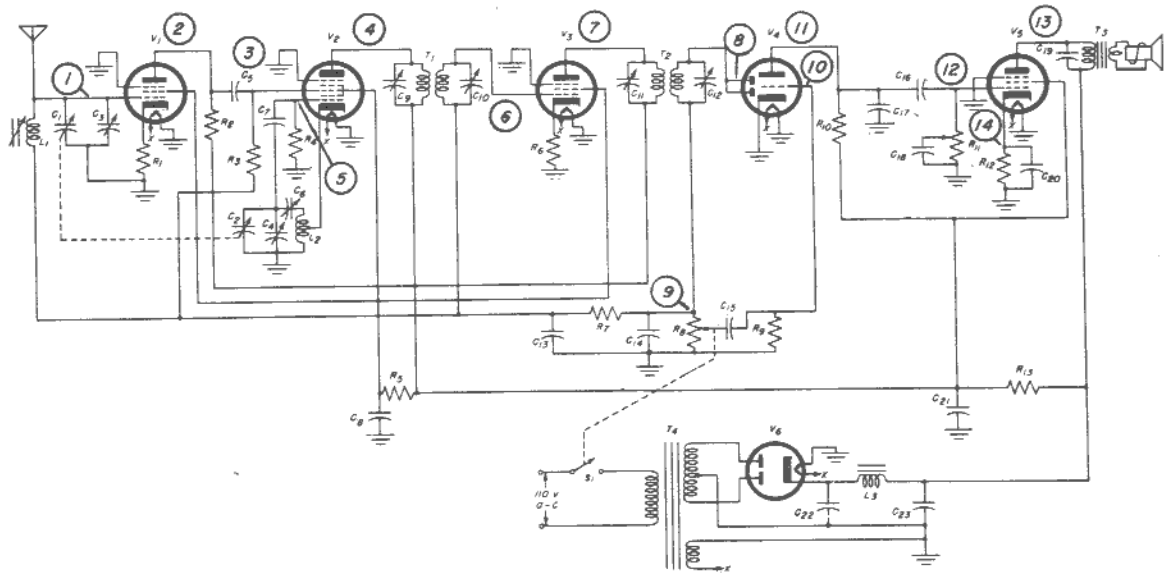


Fig. 36-12

some frequency within the broadcast band and adjust the receiver tuning dial to the same frequency. Connect the signal generator cable to the mixer grid, point 12, and rotate the receiver tuning dial back and forth slightly until you hear a signal. If you do not hear an output signal, either the mixer portion or the oscillator portion of the converter tube is not operating. Readjust the signal generator to the intermediate frequency. If you hear a signal, the mixer tube portion is operating and the trouble is in the oscillator section. You can verify this by connecting the signal generator to the mixer grid and adjusting it slowly between 1,000 kc and 2,000 kc to produce an unmodulated r-f signal. The signal generator now replaces the receiver local oscillator, and you will hear broadcast stations if there is no other defect in the receiver.

The r-f amplifier and antenna circuit are tested in a similar manner.

36-4. TROUBLESHOOTING WITH THE SIGNAL TRACER

This discussion of troubleshooting with the signal tracer is based on the schematic diagram of Fig. 36-12. This diagram shows a six-tube superheterodyne receiver, including an r-f stage. If there is no r-f stage, as is often the case, the r-f tuned circuit L_1C_1 is in the converter grid circuit, and troubleshooting is begun at this point.

In order to signal trace, you must supply a signal to the receiver, either by tuning in a strong broadcast station or by coupling in an r-f modulated signal from a generator. Choose a signal whose frequency is close to the low end of the broadcast band; the lower the frequency of the signal, the smaller will be the detuning effect of the probe capacity on the r-f circuits as the probe is touched to points in these circuits.

Apply the r-f probe of the tracer to point 1 and tune in the signal. If you cannot hear any signal at this point, the trouble may be caused by a shorted antenna coil winding or shorted tuning capacitor, a grid-to-cathode short in the tube, or an open AVC filter capacitor. If the signal heard has a different frequency than the one indicated by the dial markings, either misalignment or mistracking of the r-f circuits is indicated.

Many input circuits are of the type shown in Fig. 36-13. Such circuits use an antenna coil that has primary and secondary wind-

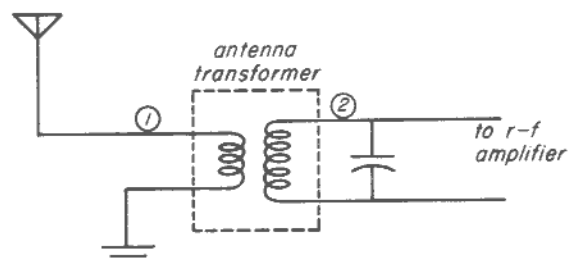


Fig. 36-13

ings. In this circuit, apply the signal tracer probe to points 1 and 2. A small gain should be expected in going from the primary to the secondary winding. If there is no signal at these points, the possible causes are the same as those given in the previous paragraph.

The next point at which to examine the progress of the signal through the receiver is at the plate of the r-f tube, point 2 in Fig. 36-12. You can expect a gain of approximately 10 to 20 times through this stage. If the stage is AVC controlled, the amount of gain will depend on the strength of the input signal. If the signal is present here, and has the proper level compared to the input, the r-f tube is operating properly as an r-f amplifier. If you do not hear the signal, or the gain is very poor, the trouble is isolated to this stage. You can then make voltage or resistance checks, or both, in order to locate the defective component. Some possible causes of trouble in this stage are improper plate or screen voltages, defective tube, open screen bypass capacitor, etc.

Next check the passage of the signal through the coupling capacitor C_5 with the tracer probe at point 3, the mixer grid. The level of the signal here should be only very slightly less than at the r-f amplifier plate. If no signal, or greatly reduced signal is present here, it may be due to a defective capacitor, or a grid-to-ground or grid-to-cathode short in the mixer tube. Either a shorted or open coupling capacitor may reduce the signal to zero at this point. An open capacitor will block the signal; a shorted capacitor will put positive voltage on the mixer grid and draw high grid current placing the grid at or near ground potential.

Operation of the superheterodyne receiver depends upon the intermediate frequency being present at the mixer plate. This frequency is produced by the interaction of the incoming signal and the locally generated oscillator signal. However, even if the oscillator is not operating, the r-f signal will appear at the plate of the mixer, point 4.

With an untuned signal tracer, it is not possible to tell whether the signal heard

when the tracer probe is touched to the mixer plate is the modulated r-f signal that is merely passing through the mixer tube or is the modulated intermediate frequency signal produced by mixing action. However, only the intermediate-frequency signal can pass through the narrow band i-f transformers. Therefore, you can test the performance of the oscillator and mixer by touching the probe of the tracer to the grid of the i-f amplifier tube (point 6). Any signal at this point must be at the intermediate frequency and shows that the i-f is being produced as a result of proper operation of the mixer and oscillator sections. If the intermediate frequency does not appear at the grid of the i-f amplifier tube, possible causes of trouble include an open or shorted oscillator coil; shorted oscillator tuning capacitor, trimmer, or padder; defective mixer tube; and improper voltages on the elements of the oscillator section of the mixer tube. Other causes include an open or shorted i-f transformer or grid-to-cathode short in the i-f amplifier tube.

In order to determine whether the trouble is in the oscillator or in the i-f transformer, check the oscillator for operation by measuring the signal developed grid bias across the oscillator grid resistor (point 5). The significance of the d-c grid voltage as a check on the operation of an oscillator has been mentioned many times previously. While the grid-leak bias of the oscillator is being checked, tune the tuning capacitor over the entire band so as to make sure that the oscillator will oscillate over the entire band.

The next test point is the plate of the i-f amplifier tube, point 7. Since the i-f amplifier tube is also controlled by AVC, the gain of the tube will depend upon the amount of the AVC voltage, which, in turn, depends upon the strength of the signal tuned in. There should be a highly amplified signal at the plate of the i-f tube. If there is not, the cause may be defective tubes, improper plate or screen voltages, misalignment of the i-f transformers, open or shorted windings, or open screen-bypass capacitors.

In most standard broadcast band receivers, only one i-f stage is used. The next test point is then at the diode plate (point 8), which is the last point tested with the r-f

probe of the signal tracer. Because of the low Q of the output i-f transformer you can expect somewhat less signal than at the i-f amplifier plate. This transformer is loaded down by the diode detector, which draws current through the transformer. Failure of the signal to appear here may be due to misalignment of the i-f transformer, open or shorted windings, or a plate-to-cathode short in the diode detector tube.

The demodulated audio output, which is recovered from the i-f signal by the detector appears across the diode-detector load resistor. This is the next test point for signal tracing. Since the signal has already been detected or demodulated, the r-f probe of the signal generator is not used, and only the audio section of the tracer is needed from this point on. Apply the audio probe of the tracer to point 9, the high side of the diode-detector load resistor. In this case, the diode load resistor is also the receiver volume control. You should hear the demodulated audio signal in the loudspeaker of the signal tracer. If you do not hear the audio signal at this point, there may be a defective detector tube, an open load resistor, or shorted diode filter capacitors.

By means of moving the audio signal tracing probe to point 10, you can check the coupling capacitor C_{15} . By continuing in this way, to the plate of the first audio amplifier, point 11, through coupling capacitor C_{16} to the grid, point 12, and plate of the output tube, point 13, you can signal trace the rest of the receiver in order to find the point where the signal disappears or becomes abnormal.

You can also use the signal tracer to check points in the circuit where no signals should be present; that is, the signal tracer can be used to check the effectiveness of screen-bypass capacitors and cathode-bypass capacitors. For example, when you apply the probe of the audio tracer to point 14, you should not hear signals, since this point should be effectively bypassed to ground by the electrolytic capacitor, C_{20} . You can make the same test with the r-f probe at the screens of the r-f and i-f tubes.

If the signal heard at any point in the audio section of the receiver is weak or distorted, you should suspect shorted coupling capacitors, gassy tubes, or improper tube operating voltages. Tests for locating any of these defects have already been covered elsewhere in this course.

However, with a signal tracing instrument available, it is possible to definitely establish whether or not distortion is being introduced by a gassy output tube. First, test the coupling capacitor to see whether it is shorted. If it is not, listen to the signal at point 12, the grid of the output tube, with the output tube both in and out of the socket. If the signal is clear when the output tube is removed, and becomes distorted when the output tube is reinserted, the source of the trouble is clearly indicated. Since the gas in the tube may not cause trouble until the tube is hot, wait until the output tube has become thoroughly heated before making this test.

Finally, you can use the signal tracer to check even the power-supply filter by connecting the audio probe to the B^+ line. You will hear some hum because no receiver power supply is designed to remove the very last traces of hum voltage. The audio amplifier in the tracer will amplify the tiny hum voltage remaining and produce a considerable output. However, by checking a number of good receivers, you can get an idea as to the amount of hum that is allowable in such a test with your particular signal tracing instrument. If there is a visual gain indicator, you can keep a record of the setting of the gain control for future reference.

36-5. ALIGNMENT OF AM BROADCAST RECEIVERS

The alignment procedure for AM broadcast receivers consists of three major parts:

1. Alignment of the i-f transformers to resonance at the intermediate frequency. Careful alignment of the i-f section gives the superheterodyne receiver its high gain and selectivity.

2. Alignment of the oscillator to make the stations come in at points called for by the receiver dial as the receiver is tuned.

3. Alignment of the r-f circuit so that it is resonant to the incoming signal as each station is tuned in by the oscillator.

It is possible to align receivers using a transmitted station signal. But more reliable results are obtained when a known signal from a generator is used for receiver alignment.

I-F Alignment. Align the intermediate frequency stages by applying a signal at the i-f frequency to point 1 in Fig. 36-14 and adjusting the trimmers C_9 , C_{10} , C_{11} and C_{12} for maximum output. Be sure to use the proper type of insulated alignment tool for making the adjustments. During the i-f alignment procedure, disable the oscillator to prevent wrong responses that may result from the input signal beating with the oscillator or its harmonics. You can do this conveniently by shorting the stator terminal of the oscillator section of the tuning capacitor to the chassis with a short clip lead.

When you are tuning the circuits for maximum response, do not rely on your ears as output indicators; your hearing is relatively insensitive to changes in volume. A number of different methods can be used to obtain an

output indication. You can connect an output meter in the circuit anywhere after the second detector to measure the audio signal. The most usual point to which an output meter is connected is either the plate of the output tube or across the voice-coil terminals. When you are using an output meter as the indicator, the input signal must be modulated. Another method is to use a d-c meter connected to the AVC line. The AVC voltage is proportional to the strength of the signal reaching the second detector and is therefore, a good resonance indicator. The meter used should have a high internal resistance so that it does not load the AVC circuit. If a high-resistance meter is not available, an alternate connection point is across the cathode resistor, which almost all i-f stages have. Any meter can be connected across this resistor without disturbing the circuit. When the meter is connected at this point, tune the i-f circuits for minimum deflection of the meter (corresponding to maximum AVC voltage).

If the i-f stages are badly out of alignment, it may not be possible to get a signal through, or oscillation may occur. In that case, apply the signal generator to point 2 and align the second i-f transformer separately. Then apply the signal to point 1 and align the first i-f transformer. During the i-f alignment process, you should occasionally check to see whether the i-f amplifier is oscillating. This

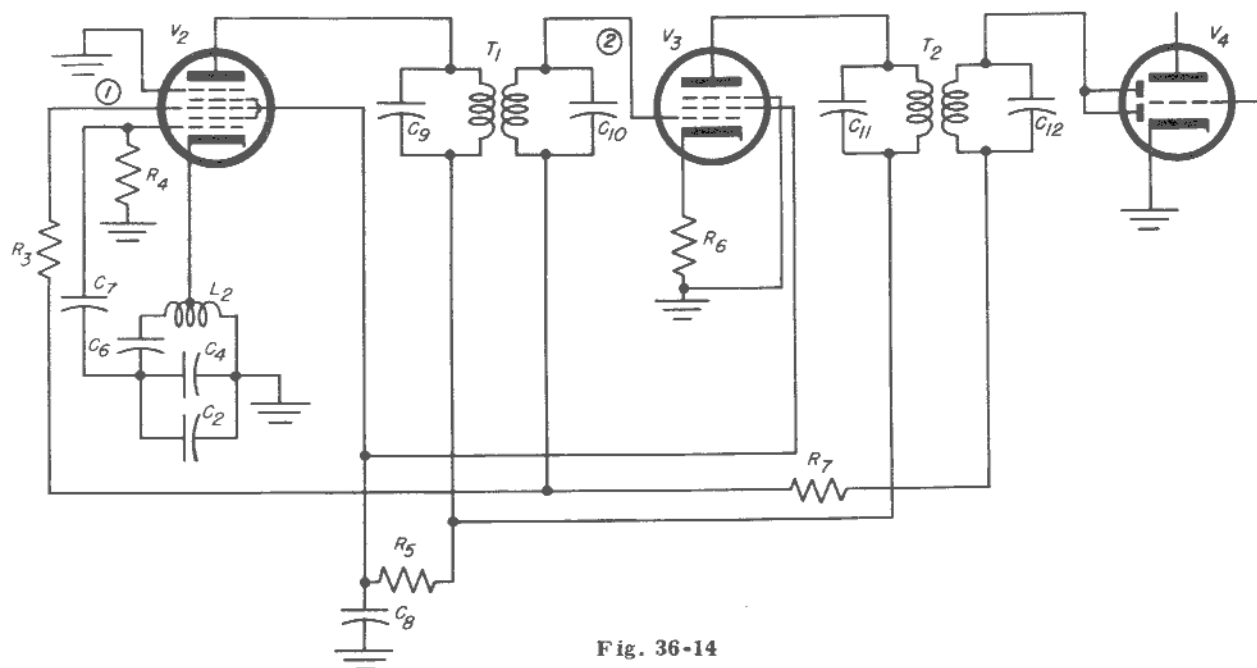


Fig. 36-14

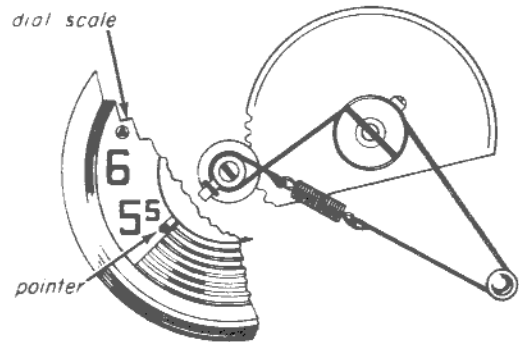
can be done by reducing the input signal with the r-f attenuation control of the signal generator. The output voltage should fall off as the input is reduced. If it does not, the i-f amplifier is oscillating. It is good practice to continually reduce the input signal as the i-f transformers are tuned closer to resonance. As a result, you will be able to detect oscillation whenever the input signal is reduced and the output does not fall off accordingly. At all times in the alignment procedure, keep the input signal low. Use no more signal than is necessary to obtain a small deflection of the meter.

In some receivers, the gain of the i-f amplifier may be so high that, when both transformers are tuned exactly to resonance, the amplifier oscillates. In such cases, since there is more than ample gain, it is permissible to detune each transformer slightly in order to obtain greater stability. Before you do this, check the receiver to make sure that either an open bypass capacitor or incorrect lead dress is not the cause of the trouble.

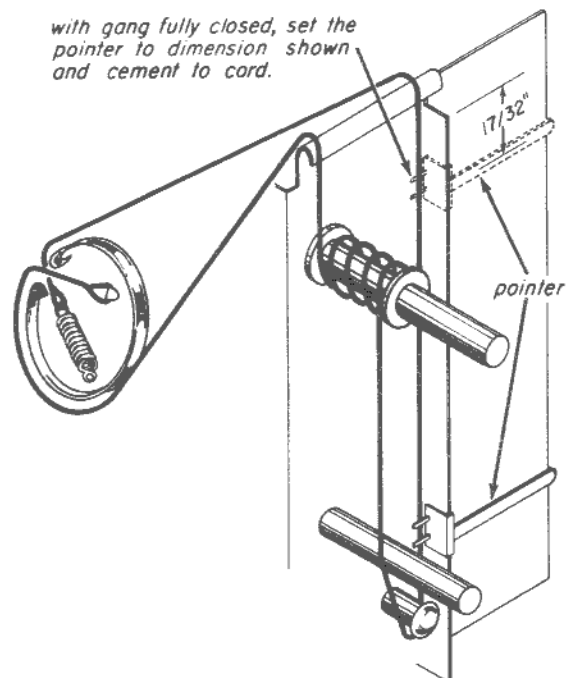
The i-f alignment procedure is the same when permeability--tuned i-f transformers are used. Be sure to use the proper type of insulated alignment tool for tuning the adjustable cores; there is danger in breaking them if you use the wrong tool.

Oscillator Alignment. The purpose of the oscillator-alignment procedure is to make the broadcast stations come in at the points called for by the receiver dial markings. The first part of this procedure is to properly mount the dial or to adjust the dial indicator to a preset reference point. Most dials have a mark at the extreme ends of the band to which the pointer is set when the capacitor is fully opened or closed. Examples of this type are shown in Fig. 36-15a for a direct drive type of dial and in Fig. 36-15b for a slide rule type of dial. If there is no such mark on the dial, consult the manufacturer's service data for the dial presetting instructions. Without a properly preset dial, the oscillator-alignment procedure is extremely difficult and time consuming.

After presetting the position of the tuning dial, tune the receiver to a quiet spot near 1,400 on the dial. Tune the signal generator to the same frequency. Remove the short



with gang fully closed and pulley set screw loosened - set pointer as above
(a)



(b)

Fig. 36-15

across the oscillator tuning capacitor and loosely couple the signal to the antenna circuit. Then tune the oscillator trimmer for maximum response on the output indicator. In many receivers, there is only one oscillator adjustment--a high-frequency trimmer capacitor. If there is no other oscillator adjustment, the oscillator alignment is complete. Usually, stations will come in correctly at the low end of the band when the high end has been aligned. If the low-end stations are very far off from the dial markings, you can bend the slotted plates of the capacitor in order to provide better tracking. When stations come in at points above the correct dial mark, too much capacity is indicated, and you should bend the slotted plates out in order to reduce the total capacity. Do not

bend the slotted plates inward, as there is too much danger of shorting them. Rather than bend the plates inward, change the dial position to make the low end track with the dial and try to realign the high end using the oscillator trimmer capacitor.

If there is a low-frequency oscillator adjustment such as a padder capacitor or an adjustable slug for the oscillator coil, it should be aligned for low-frequency tracking of the stations with the dial. Set the receiver dial to a quiet spot on the dial near 600 kc. Adjust the signal generator to the same frequency. Tune the padder capacitor or oscillator slug for maximum response. Then check the high-frequency adjustment. If it requires retuning, check the low-frequency adjustment once more. It is usually necessary to go back and forth checking the high- and low-end adjustments two or three times for best results. Always finish the alignment with the high-frequency adjustment.

R-F Alignment. When you are checking the oscillator alignment at the high end of the broadcast band, also align the r-f trimmer to give maximum response on the output meter. Adjust the trimmer on a frequency that is about 10 percent in from the end of the band, or about 1,400 kc. If there is a low frequency r-f adjustment, such as a slug-tuned antenna coil or an adjustable loop capacitor, adjust it for maximum response at the low end of the band, or about 600 kc. Some manufacturers of adjustable antenna coils recommend that the coils be peaked for maximum response at or near 1,000 kc, and this may be done if desired. Either method will give satisfactory results when all stations are strong. If you wish to get a good reception on a weak station, you can peak the r-f adjustment for best reception on this station.

Rocking Adjustment. In many AM broadcast receivers, there is no low-frequency adjustment for r-f tracking, such as an adjustable antenna coil. There is only a high-frequency r-f trimmer capacitor. Such receivers are usually designed so that there is the right amount of capacitance in the tuning capacitor for the low-frequency stations.

Most modern receivers have more than enough gain so that exact tracking is not needed except for reception of very weak stations. If you wish, you can check the tracking and adjust it, if necessary, by the rocking procedure.

The rocking adjustment is usually performed at the low end of the broadcast band, at about 600 kc. Adjust the low-frequency oscillator padder to bring in the 600-kc signal at several points above and below the 600 mark on the dial. As you tune in the signal with the padder at each of these settings of the tuning capacitor, note the maximum response. The difference in maximum response at these settings is due to the r-f circuit. Adjust the padder to make the 600-kc signal come in at the point of maximum r-f response. This point may not be at exactly 600 on the tuning dial. This discrepancy must be overlooked if best performance is desired from the receiver. However, if the tuning capacitor has slotted plates, you can bend them in order to obtain best tracking of oscillator and r-f circuit with the dial.

35-6. ALIGNMENT OF FM RECEIVERS

In order to align frequency-modulated receivers precisely, as a rule you will have to use visual alignment, using a frequency-modulated signal and an oscilloscope. However, if you are careful you can get very satisfactory results by using a signal generator and a meter.

The oscillator and r-f sections of FM receivers are similar to the corresponding stages in broadcast receivers and the procedure for aligning them is the same. However, there is a different procedure for aligning the i-f amplifiers, and the FM detector. The general procedure is given in the following paragraphs. However, whenever possible, consult the manufacturer's service data for detailed instructions as to where to inject the signal, how much signal to apply, and how to make the various adjustments.

Aligning the FM I-F Stages. The schematic of the i-f section of a typical FM receiver is shown in Fig. 36-16. Part of the limiting action of the last i-f tube is due to the grid-

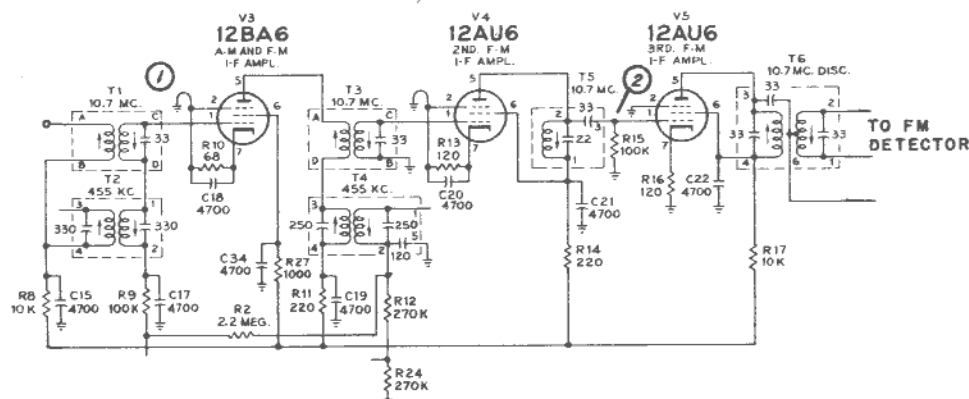


Fig. 36-16

current flow in this tube. Grid current is proportional to the amplitude of the incoming signal. Therefore, the negative d-c voltage developed across the grid-leak resistor R_{15} by grid current flowing through it is proportional to the strength of the signal and can be used as an alignment indication. In order to align the i-f stages, apply an unmodulated signal at the intermediate frequency of the FM strip to point 1, as shown in the figure, and connect a d-c meter to point 2 in the figure. As a general rule for all alignment, always separate the tuned circuit to be a-

igned from the point of signal injection by a tube. This prevents the signal generator output circuit from loading down the tuned circuit to be aligned. Adjust the i-f transformers for maximum deflection of the meter. Repeat the adjustment carefully several times, since each transformer winding has an effect on the other.

Alignment Procedure of FM Detectors. A number of different FM detectors are shown in Fig. 36-17. These are all aligned in the following manner:

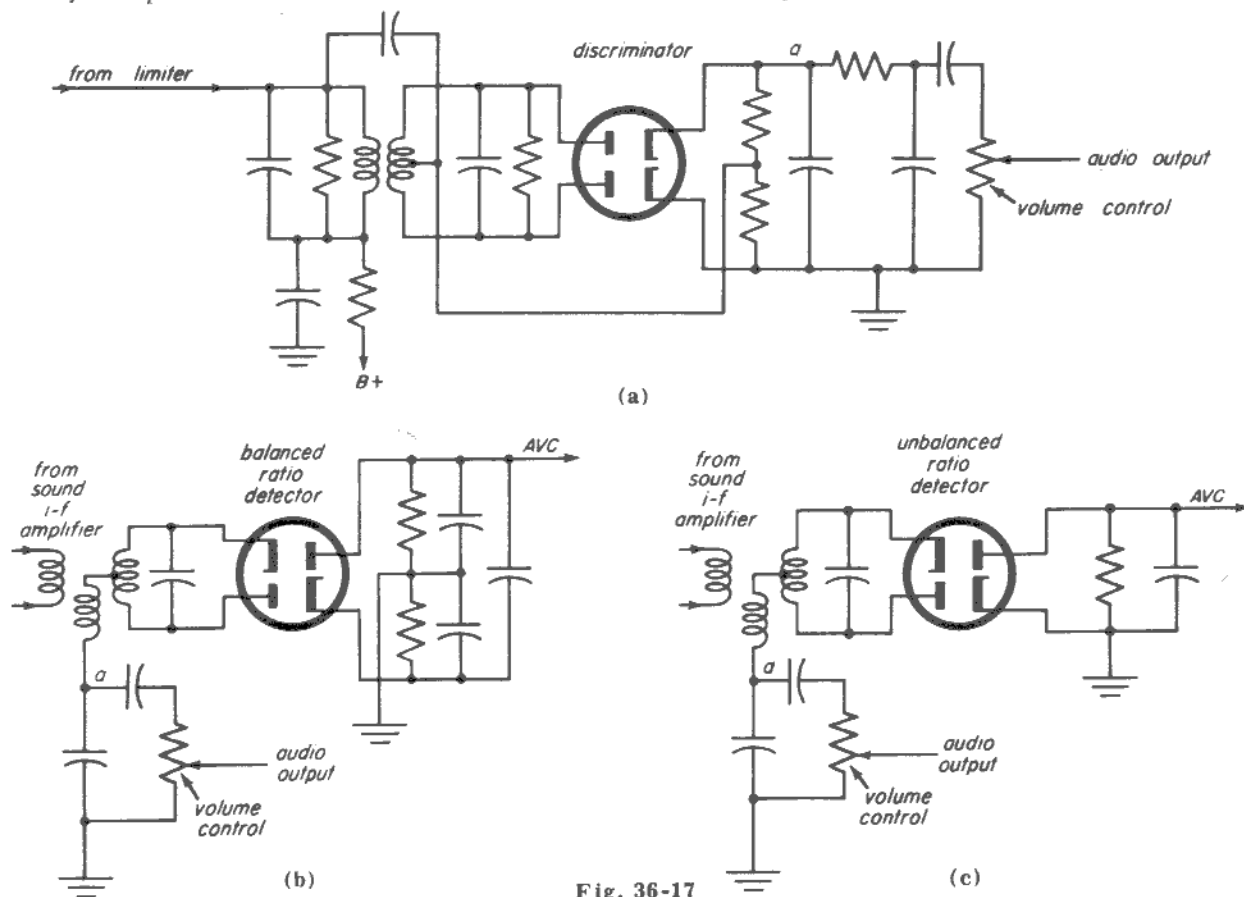
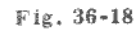


Fig. 36-17

- To align the detector, apply the CW signal (unmodulated) at the intermediate frequency to the i-f amplifier grid, and connect a d-c meter to the detector output as described above. If the meter shows zero voltage, detune the secondary slightly until a small voltage is obtained. An isolating resistor of from about 100 k-ohms to 1 megohm should be used in series with the meter to prevent the meter from detuning the detector circuit. Use the largest resistor that will still allow a usable deflection on the meter. Tune the primary for maximum deflection, and then retune the secondary for exactly zero voltage. Repeat the adjustments once or twice, since each affects the other. Make sure that the secondary is tuned to point 2 in Fig. 36-18, and not to points 1 or 3, as each of these will give zero voltage. The tuning can be checked by turning the secondary adjustment in one direction the d-c voltage should rise sharply positive, and in the other direction the d-c voltage should rise sharply negative. After the tuning has been checked in this way, the secondary should be very slightly mistuned to give a very small deflection on the meter. Then peak the primary again for maximum output deflection, and retune the secondary to give exactly zero volts output. The detector alignment is complete.



Aligning the Gated-Beam FM Detector.

A typical circuit of the gated-beam type of



FM detector is shown in Fig. 36-19. This circuit may be aligned by applying an FM *sweep* signal centered at the i-f frequency to point 1 in the figure. An output meter is connected across the voice coil for use as a resonance indicator. Adjust the quadrature tank circuit for maximum audio output. Ad-

just the variable cathode resistor for minimum amplitude modulation and buzz in the audio output. It is best to consult the manufacturer's service data for the recommended method of adjusting the cathode resistor and the amount of input signal to inject when adjusting the quadrature tank circuit.

